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GLOOM:

A Computerized Oligopoly Game

Richard L. Schmalensee

September 1968 351-68

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TABLE OF CONTENTS

page

I. Introduction to GLOOM 1

II. Basic Mechanics 5

III. Demand Parameters and Output Codes 15

IV. Entry, Sales, and Profits 23

V. Best and Expected Prices 27

VI. Ratings 32

Appendices

A. Mnemonic Formats of Input Cards 38

B. Mnemonics used in GLOOM 41

C. Description and Listing of GRNUM 45

D. Listing of GLOOM, the Main Program 48

E. Listing of Subroutine RGIN 56

F. Listing of Subroutine PGOUT 61

G. Listing of Subroutine CAR 69

H. Sample Output 72

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I

Introduction to GLOOM

The original version of GLOOM (Game in the Logic of Operating in an Oligopoly Market) was an oligopoly pricing game written in the fall of 1967. It was designed to be used in conjunction with a classroom discussion of theoretical and observed behavior in concentrated markets. GLOOM has been employed both at the Sloan School (in two courses) and at the Amos Tuck School, Dartmouth.

The new version of GLOOM is also an oligopoly pricing game, but it provides both students and instructor with more choices and more information than did the old GLOOM. It should be much more interesting for all involved, and it has greater potential as a research tool. The new GLOOM was written in the summer of 1968. The author would like to thank the Sloan School for financial support and Paul MacAvoy for proposing this project and providing invaluable advice and suggestions. All errors are, of course, my own.

Students playing GLOOM are divided into firms. Each firm begins with fixed costs of $50,000 and variable costs of $.50 per unit. All firms have a capacity of 100,000 units. Each firm must post a price in each period; its sales will then be calculated as a function of its price, the prices of other firms selling in the same market, and a random element. Students are told that in the preceding period all firm charged $1.00, and all sold 100,000 units.

The instructor may vary the demand structure from industry to industry. He may also elect to vary the legal framework. To date, students have been

subject to three sets of laws:

1. The Sherman Act: All conspiracies in restraint of trade are illegal.
2. The English Common Law: Firms may collude on price and/or agree to make side payments, but such agreements are not enforceable.
3. The (representative) German Kartell Law: Firms may collude on price and/or agree to make side payments, and any such agreements are enforceable.

Penalties for conspiracy or for violating enforceable cartel agreements must be imposed by the instructor: he is the enforcer.

GLOOM provides three other options. First, it may be specified that entry into one or more industries is allowable. It if is, a fixed cost per period will be charged any entrant, and he will lower the demand curves of firms already present. The entry costs should, of course, be revealed. Second, firms operating in some industries may be permitted to make and accept side payments. Payments made to a firm ineligible to receive them will be debited to the payer but not credited to the payee. Payments made by a firm ineligible to make them will be ignored. Negative side payments will be treated as positive. Again, students should be told in which industries side payments are allowed.

Finally, the instructor can vary the amount of information given firms operating in each industry about conditions in other industries and about the actions of their competitors. If certain figures are not available to a firm, they will show as zeros on its output.

The mechanics of GLOOM from the point of view of the student are almost absurdly simple. Runs will be made each day. Each firm must submit a firm card, punched as shown in Exhibit I.1, which will remain in force until a new card is submitted. Identification must, of course, be shown before anyone is allowed to replace a firm card.

The only item in Exhibit I.1 that requires comment is the number of copies of interim output to be printed. Unless there is a very good reason to the contrary, this number should be set at one, to save computer time.

At the end of the game, each student will receive a copy of summary output, giving information not provided by the interim output. Each student should be required to write a short paper analyzing the experience of his firm. Grades on the overall exercise should be based on some weighted combination of the grades on these papers and the earnings of the various firms.

Chapter II will discuss the mechanics of GLOOM from the point of view of the instructor. Chapter III will go over the parameter specifications he can make. Chapter IV discusses the effects of entry and exit and outlines the method used to calculate sales, profits, and unfilled orders. Chapters V and VI discuss the calculation and interpretation of certain figures appearing on the instructor's output which are used to evaluate firm and industry performance.

Appendix A lists the mnemonic formats for all input cards to GLOOM. Appendix B explains the mnemonics used in this paper and the computer programs. Appendices C - G list the programs that compose GLOOM, and Appendix H gives sample output.

Exhibit I.1

Format for Firm Cards

Columns	Contents
01 - 04	The four digit (no decimal point) firm number - to be assigned. Consists of a two digit original industry number and a two digit firm number.
05 - 06	The industry the firm is to operate in, if different than the original industry.
07	The number of copies of interim output to be printed.
08 - 13	The price to be charged (punch a decimal point).
14 - 17	The four digit firm number of the firm to which a side payment is to be made - if any.
18 - 25	The amount of the side payment - if any (punch a decimal point).

II

Basic Mechanics

This chapter will describe the mechanics involved in making a GLOOM run and in administering the exercise as a whole. GLOOM is composed of a main program called GLOOM and four subroutines: GRNUM, RGIN, PGOUT, and CAR. These routines are listed in Appendices C through G as written in Fortran II for the 1620 II system at the Sloan School. This version can handle a maximum of ten industries with a maximum of ten firms operating in them. (Normally, of course, you will begin with four or fewer firms in each industry.) Conversion to other Fortran systems should present few problems, as only GRNUM (the random number generator) would need to be changed to fit the machine.

These programs take up a lot of space. So much, in fact, that it is necessary to treat RGIN, PGOUT, and CAR as LOCAL subroutines. That is, they are kept on the disk until called by the main program, at which time they are read into core storage. (This adds some time to each run.)

Basically, RGIN does most of the reading, GLOOM most of the calculation, and PGOUT most of the printing. CAR updates some average ratings which are useful in evaluating performance and which will be discussed below, especially in Chapter VI. GRNUM is used to provide the stochastic terms in firm demand functions. Appendix B may be helpful in understanding what operations are being performed by the programs.

We now turn to a discussion of an input deck to GLOOM. We will then discuss the printed output produced by the program. Finally, we will

make a few remarks on how to make GLOOM an ungloomy experience for all concerned.

Input

Exhibit II.1 indicates the makeup of a GLOOM input deck. It assumes that the programs listed in Appendices C - G have been loaded on the disk.

The first two cards must be punched exactly as shown. We will discuss the title card and industry cards below. The format for the firm cards was presented as Exhibit I.1. History cards are punched automatically by CAR at the end of each run; they are then used as input to the next run. For the first period in any game, no history cards are required (or available).

The format for the title card is shown as Exhibit II.2. The first output from GLOOM is a new title card for the next period; so if nothing but the period number if to be changed, a title card need only be punched once. It will usually be desired to obtain only one copy of the parameter summary for each game, however, and only the average rating summary produced at the end of the final period. In this case, a title card must be punched for the first and last periods. Columns 01 - 10 should contain no decimal points.

The format for the industry cards is given as Exhibit II.3. Normally, no changes will be made in an industry card within a game. If there are four industries, they must be named 01, 02, 03, and 04. Similarly, if three firms started out in industry 02, they must be named 0201, 0202, and 0203. The program will absolutely not work otherwise.

The rules governing side payments were given in Chapter I. The Output Codes will be discussed in Chapter III, along with the meaning and use of Monopoly Price, Critical Price, and FK. It should be mentioned here, however, that either Critical Price or FK should be punched, but not both. If both are punched, Critical Price will be ignored, in the sense that the Critical Price used by the program and reported in the parameter summary will be calculated from FK.

If neither entry cost is punched, the program will assume entry is not allowed, and the entry code will be set to zero. If either is punched, the entry code will be set to one, and the entry cost in dollars will be calculated from whichever figure is given. If both are punched, the columns giving entry cost as a percentage of original monopoly profit will be ignored. The use of the standard deviation of the error term and the effects of entry will be taken up in Chapters III and IV.

One final note: If columns 13 and 14 contain "-1", each firm will receive as many copies of summary output as they requested copies of interim output (in column 07 of the firm card).

Output

GLOOM produces two punched outputs which were mentioned above: a title card for the next period and a set of history cards to be used in the next period. In addition, the following printed outputs may be produced:

1. Parameter Summary
2. Side Payment Summary
3. Instructor's Output

4. Students' Summary Output
5. Students' Interim Output
6. Average Rating Summary

Appendix H contains examples of all these. The parameter summary summarizes the parameter specifications made on the industry cards. "STD.-DEV" is the standard deviation of the error term in thousands of units. The entry cost shown is in dollars; it is zero if entry is not allowed.

The side payment summary lists side payments made by firms eligible to make them. (As mentioned in Chapter I, payments made by other firms are ignored.) Payments made to firms ineligible to receive them are noted.

Most of the instructor's output is self-explanatory. The various Ratings will be discussed in Chapter VI. "BEST PRICE" and "EXP. PBO" will be taken up in Chapter IV. "ACT. PBO" is the arithmetic average of competitors' prices, except in the case of a single firm, when it is the firm's own price.

The students' summary output is designed to be given to students at the conclusion of the game, when they are required to write papers on their firm's experience. The information on the students' interim output may contain all the information on the summary output except data on firms in the original industry for firms that have entered other industries. The information actually given to firm operating in each industry is governed by the output codes for that industry, as discussed in Chapter III. Appendix H contains examples of the maximum and minimum amounts of information that may be revealed.

The history cards contain the same information as the average rating summary. Subroutine CAR averages them with the current period ratings, as shown on the Instructor's Output, to produce new history cards and a new average rating summary. The averaging, of course, takes into account the number of periods on which the history cards are based.

Some General Remarks

GLOOM is not really difficult to run. A light reading of this manual is all that is required to understand how to make out the title card and industry cards. Once this is done, only a very short computer run each day is required.

Runs should be made every day so as to minimize the artificial nature of the experience. If runs are made less frequently, students tend to regard them as disjoint events instead of snapshots of a continuous process. It should be emphasized, however, that until a firm card is replaced by a new one the price and other information given on it continue to hold.

It has been the author's experience that GLOOM moves students to heights of treachery almost unknown in actual industrial experience: conspiracy, sabotage, and espionage are common. Industries under the Sherman Act do conspire to raise prices. Student companies in GLOOM deliberately conspire to beat the game, without sufficient regard for the penalty (a zero grade on the exercise). The real problem, however, has to do with bogus firm cards submitted by competitors. Tight security should be maintained. The secretary keeping the firm cards should require positive identification of anyone attempting to replace any firm's card, because

students have deliberately replaced cards of other teams with ones containing destructive orders (such as million dollar prices). Similarly, interim output should be given only to those who can prove that they are in fact members of the firm whose printout they request.

The oligopoly problem remains even if students know the demand structure. While obviously nothing is gained by revealing it to them, they should not be discouraged from trying to estimate it.

Finally, about grades. Clearly the papers that are required at the end of the exercise should be important. But it is also clear that some weight should be given to the profits earned by each firm -- otherwise there is no incentive to maximize. Since demand parameters will usually vary from industry to industry and since sales do depend on a stochastic term, dollar profits are unsuitable as a grading index. The Ratings are designed to fill this gap. Rating A is probably the best for grading purposes; see Chapter VI for details.

Exhibit II.1

The Makeup of an Input Deck

1. A card with "**XEQSGLOOM" punched in columns 1 - 11 and "01" punched in columns 29 - 30.

2. A card with "*LOCALGLOOM, RGIN, PGOUT, CAR" punched in columns 1 - 26.

3. A TITLE CARD.

4. INDUSTRY CARDS, one for each industry (may be in any order).

5. FIRM CARDS, one for each firm (may be in any order).

6. HISTORY CARDS, if not running the first period.

Exhibit II.2

Format for Title Card

Columns	Contents
01 - 02	The number of industries
03 - 04	The period (run) number
05 - 06	The number of copies of the parameter summary to be printed
07 - 08	The number of copies of the side payment summary to be printed
09 - 10	The number of copies of the average rating summary to be printed
11 - 80	A comment, which will appear at the top of all printed output

Exhibit II.3

Format for Industry Cards

Columns	Contents
01 - 02	Industry number
03 - 04	The original number of firms
05 - 06	The side payment code: 1 if they are permitted, 0 if not
07 - 08	The number of copies of instructor's output to be printed
09 - 10	Output Code - gives information to be printed on other industries
11 - 12	Output Code - gives information to be printed on competitors
13 - 14	The number of copies of students' summary output to be printed for each firm
15 - 20	Monopoly Price (punch a decimal point)
21 - 26	Critical Price (punch a decimal point)
27 - 34	FK (punch a decimal point)
35 - 40	Standard deviation of the "error term" as a percentage of capacity -- that is, in thousands (punch a decimal point)

Exhibit II.3 (continued)

Columns	Contents
41 - 46	Entry cost as a percentage of original monopoly profit (punch a decimal point)
47 - 54	Entry cost in dollars (punch a decimal point)

III

Demand Parameters and Output Codes

Three items on the industry cards are used to determine the demand functions in each industry: monopoly price (PM), critical price (PC), and a quantity we called simply FK. Each firm's demand curve is of the form

$$Q = A - BP + C\overline{P} + e \tag{3.1}$$

where $\overline{P}$ is the arithmetic average of his competitors' prices and e is a normally distributed error term. A, B, and C are, of course, positive.

In Chamberlinian terms, the firm demand schedule is given by (3.1), and the industry demand curve by

$$Q = A - (B - C)P + e \tag{3.1a}$$

When solved for P, these correspond exactly to DD' and dd' in figure 14, page 91, of the eighth edition of The Theory of Monopolistic Competition. This chapter will indicate how PM, PC, and FK are used to assign numerical values to A, B, and C. We will deal with the case of no entry or exit, as the next chapter will take up the implications of a change in the number of firms. We will also generally assume zero error terms.

In addition, the final section of the chapter will list and explain the output codes referred to in Chapter II.

Monopoly Price

Essentially, we need three equations to assign values to the three unknowns A, B, and C. The first is provided by the condition mentioned in Chapter I as holding for all industries: if all firms charge a price of $1.00, all will sell 100,000 units. In equation form, this becomes

$$100{,}000 = A + (C - B). \tag{3.2}$$

The second equation comes from the monopoly price. If all firms charge the same price, the profits of any one are

$$PR = (A + P(C - B))(P - .50) - 50{,}000. \tag{3.3}$$

If all firms are charging the monopoly price (PM), the derivative of (3.3) with respect to P is zero. This yields the condition

$$2A + (C - B)(4PM - 1) = 0. \tag{3.4}$$

If we solve the system (3.2) and (3.4), we can obtain

$$(C - B) = -\frac{200{,}000}{4PM - 3} \tag{3.5a}$$

$$A = \frac{100{,}000\,(4PM - 1)}{4PM - 3} \tag{3.5b}$$

We are not quite finished, but these results deserve some comment. Notice that for a given standard deviation of the error term, the higher the price the greater the standard deviation of profits. Risk aversion may lead to prices less than PM if the standard deviation of e is large. Thus the identification of PM as monopoly price holds exactly only when

error terms are zero or when firms maximize expected profit. We will hold to the latter assumption throughout.

Substitution of equations (3.5) into (3.3) leads to an expression for monopoly profit:

$$\text{PRM} = \frac{200,000\ (\text{PM} - 1)^2}{4\text{PM} - 3} \tag{3.6}$$

This is the average monopoly profit per firm when there has been no entry or exit. It is easy to show that PRM rises with PM. That is, the higher the monopoly price in an industry, the higher the profits that can potentially be earned by firms operating there.

Critical Price and FK

Critical Price (PC) and FK are two equivalent ways of expressing the responsiveness of firms' demand to differences in P and $\overline{P}$. It will be shown in Chapter V that the lower PC is or the higher FK is, the more profitable it is to cheat by price-cutting. We will show below the precise meaning of these quantities.

If we let $P = \overline{P} - X$, a firm's profits are given by

$$\text{PR} = (A - B(\overline{P} - X) + C\overline{P})(\overline{P} - X - .50) - 50,000 \tag{3.7}$$

The derivative of PR with respect to X evaluated at X = 0 is given by the expression

$$V = -A + (B - C)\overline{P} + B\overline{P} - B/2. \tag{3.8}$$

V can be interpreted as the added profit from charging a price just slightly below the competition when no attention is paid to capacity limitations. Notice that V rises with $\overline{P}$, since we have already shown that (B - C) is positive. Thus, if V is zero for some $\overline{P}$, it will be positive for higher $\overline{P}$ and negative for lower $\overline{P}$.

There are two equivalent paths we can follow from here. The first is to set the value of V for $\overline{P} = 1$. We denote that value as FK; it is the marginal profit that could be earned by shaving price just slightly if competitors were charging $1.00 and if there were no capacity constraints. If FK is positive, it will generally always pay to price slightly below the competition. If we do this, we have our third equation as

$$FK = -A + 3B/2 - C. \tag{3.9}$$

If we combine this with equation (3.5a), we find

$$B = 2FK + 200{,}000 \tag{3.10a}$$

$$C = 2FK + \frac{800{,}000(PM - 1)}{4PM - 3} \tag{3.10b}$$

On the other hand, we can fix the price for which V is zero. This is the price that we have called the Critical Price, or PC. This will also yield our third equation:

$$0 = -A + 2\ B\ PC - C\ PC - B/2 \tag{3.11}$$

Using this and (3.5a) we obtain

$$B = \frac{100,000(4PM - 1 - 2PC)}{(4PM - 3)(PC - \frac{1}{2})} \tag{3.12a}$$

$$C = \frac{400,000\ (PM - PC)}{(4PM - 3)(Pc - \frac{1}{2})} \tag{3.12b}$$

It should be clear that B and C will both be positive only if PC is between $\frac{1}{2}$ and PM. (Equations (3.10) give the corresponding condition on FK: it must be larger than -100,000 and -400,000(PM - 1)/(4PM - 3) for B and C to be positive.)

It may be instructive to examine the relation between PC and FK. If we equate (3.12a) and (3.10a) and solve for FK, we obtain

$$FK = \frac{400,000\ (2PM - 1)\ (1 - PC)}{(4PM - 3)(2PC - 1)} \tag{3.13}$$

It is clear from this that a larger FK corresponds to a smaller PC: the more the profit to be made at $\overline{P} = 1$, the lower the price at which zero profit is made. Finally, if PC is less than one, the corresponding FK may need to be fairly large. For instance, if PC = .90, the corresponding FK is 30,000 with PM = 2. In the limit as PM becomes very large, the equivalent FK approaches 25,000.

Each industry card must contain a value for Monopoly Price. It also must contain either an FK or a Critical Price. If both are punched, the Critical Price will be ignored, and the Critical Price shown on the parameter summary will be calculated from equation (3.13) solved for PC.

Output Codes

This section will explain the output codes mentioned in Chapter II. Code 1 is a two digit number which indicates the information to be given on other industries to firms operating in the industry in question. The first digit deals with average price and the current number of firms; the second controls printing sales and profits. The codes are as follows:

Code 1

First Digit	Meaning
3	Print the actual number of firms and their average price
2	Print only their average price
1	Print only the number of firms
0	Print none of this information

Second Digit	Meaning
3	Print both total sales and total profits
2	Print only total profits
1	Print only total sales
0	Print none of this information

Each firm will always be given total sales, total profits, and average price for its industry. As mentioned in Chapter I, if any figure is not available to a firm, it will be printed as a zero -- except when code 1 is 00, when no line will be printed. An example may help. If code 1 is 12 for industry i, firms operating in industry i will receive on their interim output the number of firms present and the total profit received in all other industries.

The second output code, code 2, determines the information to be provided to a firm about its competitors. It will always be told the average price, total sales, and total profits earned in the industry it is operating in. Code 2 determines the additional data it will receive as follows:

Code 2

First Digit	Meaning
3	Print the number of firms and the four digit firm numbers of all competitors
2	Print the number of firms and the four digit firm numbers of those competitors who have entered this industry from elsewhere
1	Print only the number of firms
0	Print none of this information

Second Digit	Meaning
7	Print all prices, sales, unfilled orders, and profits
6	Print all profits, sales, and unfilled orders
5	Print all prices and profits
4	Print all prices, sales, and unfilled orders
3	Print all profits
2	Print all sales and unfilled orders
1	Print all prices
0	Print none of this information

Again, any figure not available to a firm will be printed as a zero. If code 2 is 33 for industry i, for example, all firms operating in industry i will be told the firm numbers of their competitors and the profits each received. Appendix H provides examples of output generated by codes 00 00 and 33 37.

IV

Entry, Sales, and Profits

This Chapter will discuss the effects of net entry or exit and the mechanisms for calculating sales and profits. The former are quite basic to the GLOOM environment. It takes a while to explain the method for allocating unfilled orders among firms with excess capacity, but it is not of earth-shaking importance. It almost suffices to say that firms charging low prices pick up more unfilled orders from their competitors than firms charging high prices, while firms charging very high prices never receive unfilled orders. For more details, read the second part of this chapter.

Entry

Suppose that a particular industry began with NI firms operating in it. Suppose further that it now has NA firms present. We calculate

$$F = \frac{NI}{NA} \tag{4.1}$$

We then multiply A, B, C, and the standard deviation of e in equation (3.1) by F. (Recall that these parameters were calculated by equations (3.5b) and (3.10) from the information on the industry card.) All the discussion in this and the following two chapters assumes that these transformations have already been carried out.

Notice that if the industry average price is unchanged, entry or exit will leave (average) total sales unchanged. The effect of net entry is to

divide the original market among all firms present; if there is net exit the "leavings" are divided among all firms remaining behind. The standard deviation of the stochastic term in firms' demand functions rises and falls inversely with their number: a smaller piece of the action means less absolute variation.

There are several interesting implications of this scheme. First, it is easy to show that the own-price elasticity of demand is unchanged if the firm's own and competitors' average prices are unchanged. But Chapter V will show that the best chiseling strategy may nonetheless be altered.

Monopoly price is unchanged by entry or exit and if charged by all firms it will give rise to the same total industry demand. But if there has been net exit, the remaining firms may not have the capacity to sell monopoly output. In this case, the monopoly price will yield unfilled orders and a cartel would be better off setting a higher price. This is almost certain to happen if only one firm remains in an industry. Chapter VI discusses this point further.

While the monopoly price specified on the industry card continues to hold in this fashion, FK and Critical Price are changed. Equation (3.9) defines FK in terms of A, B, and C. It should be quite clear from this equation that net entry decreases FK and that net exit has just the opposite effect. (Equation (3.13) implies that a decrease in FK is equivalent to an increase in Critical Price) Thus one may find that even with a positive FK, after net entry there may exist a range of prices within which it will pay a firm to charge above its competition.

In general, though, these are changes in the right direction. We would expect cheating to be more profitable (see Chapter V) the fewer the firms present -- assuming, of course, no retaliation.

Sales

For convenience, let us reproduce the basic demand equation:

$$Q = (A + e) - BP + C\overline{P} \tag{4.2}$$

(GLOOM in fact does add the error term onto the intercept term of the demand function, as shown here.)

The first step in the determination of sales in an industry is to substitute each firm's price (P), the arithmetic average of its competitors' prices ($\overline{P}$), and its error term (e) into (4.2). The firm's demand is taken as the larger of Q so calculated and zero; negative sales are not allowed. Total demand for the industry is calculated as the sum of these demands. Each firm's share of total demand is calculated as the ratio of its demand to the total for the industry.

If all of the firm demands are for less than 100,000 units, sales are set equal to demands, and the program proceeds to other tasks. If the demand of the i^{th} firm, D_i, is greater than 100,000, however, it will have sales of 100,000 and unfilled orders of (D_i - 100,000). The question now is who gets the business of these frustrated demanders.

We first calculate the total of the demands accounted for by firms with excess capacity. We then compute the share each of these firms contributed to this total. Each then receives a fraction of total unfilled

orders in the industry equal to this share. If this allocation raises some demands above 100,000, the unfilled orders so produced are allocated in this same fashion. The procedure stops when either (1) no new unfilled orders have been generated by an allocation (i.e., all firms which had excess capacity before the unfilled orders were allocated still have excess capacity) or (2) all firms have unfilled orders. Needless to say, condition (1) occurs almost all the time.

If this has been confusing, you might try a look at the Fortran shown in Appendix D. It is important to remember that UNFILLED ORDERS on the printed output refers to the extent to which demand was greater than capacity, not to the number of orders picked up from sold-out competitors. That figure is buried in total sales. In any case, the disposition of unfilled orders is not likely to affect either the fortunes or the strategy of any firm very much.

Profits

Once sales have been determined for all firms, profits are trivial to compute. The general formula is

(4.3) Profits = Sales (Price - .50) - $50,000

- Entry Cost (if the firm began operations in a different industry)

+ Side Payment Received (if any)

- Side Payments Made (if any)

V

Best and Expected Prices

If a firm knew the demand parameters and what its competitors were going to charge, it could quite easily calculate its short-run profit-maximizing price. GLOOM calculates this best price for all firms given what their competitors actually did charge. Where entry is permitted, the program calculates the profit-maximizing entry price. These two figures and a third, called "expected price", appear only in the instructor's output. This chapter will derive and explain them in turn.

Best Price

Suppose a firm knows that its competitors will charge an average price of $\bar{P}$. Its demand curve as a function of its own price P is given by

$$Q = A - BP + C\bar{P}. \tag{5.1}$$

(The firm is assumed to make decisions using the expected value of its error term, which, of course, is zero.) Ignoring its fixed costs, for Q less than or equal to 100,000 profits are given by

$$PR = (A - BP + C\bar{P})(P - \tfrac{1}{2}) \tag{5.2}$$

Differentiating (5.2), setting the result equal to zero, and solving for P, we obtain

$$P^*_1 = \frac{A + C\bar{P}}{B} + \tfrac{1}{4} \tag{5.3}$$

This price may, however, imply sales of greater than 100,000 units. If this is the case, the firm should charge the highest price that will enable it to sell 100,000 units. That price is found by setting Q = 100,000 in (5.1) and solving for P:

$$P^*_2 = \frac{A + C\overline{P} - 100{,}000}{B} \tag{5.4}$$

Clearly the best price is given by the maximum of P^*_1 and P^*_2; this is how GLOOM computes it. It is straightforward to show from equations (5.3) and (5.4) that P^*_2 is greater than P^*_1 whenever $\overline{P}$ is greater than

$$P^{**} = \frac{B + 400{,}000 - 2A}{2C} \tag{5.5}$$

If there has been no net entry, P^{**} can be expressed as a function of PM and FK (see Chapter III) as follows:

$$P^{**} = \frac{FK + W}{2FK + W}, \text{ where } \qquad W = \frac{800{,}000\ (PM - 1)}{4PM - 3} \tag{5.6}$$

Thus P^{**} will always be less than one for positive FK, and it will then always be optimal to use P^*_2, to set demand equal to capacity.

If there has been net entry, however, P^{**} will rise and P^*_1 may become the best price: A, B, and C are multiplied by some number less than one, but 400,000 is unchanged. On the other hand, net exit lowers P^{**}.

If a firm is alone in an industry, its best price is the larger of PM and P^*_2. It is often the case that PM will result in unfilled orders, since the demand curve has usually been shifted out a great deal.

If there has been no net entry, we can express P^*_2 in terms of $\bar{P}$, PM, and FK as follows:

$$(5.7) \qquad P^*_2 = \frac{\bar{P}\ FK\ (4PM - 3) + 100{,}000\ (1 + 4\bar{P}\ PM - 4\bar{P})}{(4PM - 3)(FK + 100{,}000)}$$

It can be easily verified that

$$\frac{2P^*2}{2PM} = \frac{400{,}000\ (\bar{P} - 1)}{(4PM - 3)^2\ (FK = 100{,}000)} \quad ,$$

which is positive for $\bar{P}$ greater than one. That is, since P^*_2 is normally the best price, a higher monopoly price implies, ceteris paribus, a higher profit-maximizing price for any average competitors' price. A rational "cheater" will charge a higher price the higher PM is, and he will find cheating more profitable since he will still sell 100,000 units.

Differentiating (5.7) with respect to FK, we find

$$\frac{2P^*2}{2FK} = \frac{100{,}000\ (\bar{P} - 1)}{(4PM - 3)\ (FK + 100{,}000)}$$

So again, the larger FK (the smaller PC), the higher the cheater's price and the more profitable it is to cheat.

It must be emphasized that "best price" is a tactical measure. If an industry has a well organized cartel, these calculations will yield the price each firm should charge if it wishes to cheat on the cartel. Such cheating may not be optimal in the long run, however, when the firm considers the retaliation it may face.

Entry Price

Calculation of the best entry price follows essentially the outline above, except for one preliminary step. The actual industry average price is used for $\bar{P}$, but the demand parameters must be changed to allow for the effect of the hypothetical entry.

If N firms are in the industry, an entrant would cause the parameters A, B, and C to be multiplied by $N/(N + 1)$. If there are no firms in the industry but K firms started out there, an entrant would face parameters equal to K times their no-entry values.

Once the values of A, B, and C that an entrant would face are computed, the entry price is calculated as outlined above; and the profits such an entrant would earn are calculated as usual -- allowing for entry costs, of course.

Expected Price

If a firm sets a price P, expecting it to be P^*_1, it must have expected (5.3) to hold. Solving for $\bar{P}$, we find the average price it expected its competitors to charge:

$$\bar{P}^e_1 = \frac{4BP - 2A - B}{2C} \tag{5.8}$$

If, on the other hand, it was attempting to set $P = P^*_2$, we can solve (5.4) to obtain

$$\bar{P}^e_2 = \frac{BP - A + 100,000}{C} \tag{5.9}$$

Given a value of P, we must now decide which of these the firm actually expected its competitors to charge. We found above that P^*_2 is profit-maximizing whenever $\overline{P}$ is greater than P^{**}, as given by (5.5). The firm can be said to have "expected" $\overline{P}^e_2$ only if P^*_2 would have been optimal if the average price of its competitors had indeed been $\overline{P}^e_2$. The condition that $\overline{P}^e_2$ be greater than or equal to P^{**} reduces to the condition that P be greater than or equal to

$$(5.10) \qquad T = \frac{100{,}000}{B} + \tfrac{1}{2}$$

Since P will almost always be greater than one, this condition will hold for all positive FK (or all PC less than one). It is easy to show that P less than T is equivalent to $\overline{P}^e_1$ less than P^{**}. Thus any price greater than T carries with it the implication that the firm "expected" $\overline{P}^e_2$, since if its competitors had charged $\overline{P}^e_2$ its price would have been optimal. Similarly, if its price is less than T, $\overline{P}^e_1$ would make it optimal. Again, it should be clear that this whole discussion has assumed that the firm is trying to maximize current period profits only.

The instructor's output gives the actual average competitors' price as "ACT. PBO" and the appropriate expected price as "EXP. PBO". Fractions of cents are not shown.

VI

Ratings

This chapter will explain the four ratings that are calculated by GLOOM and that appear on the instructor's output and the average rating summary. The reason for having ratings at all was mentioned in Chapter II: it is desirable to have some yardstick of performance that does not depend on the particular demand parameters in each industry and that is not dominated by the stochastic term in the demand function. Dollar profits do not meet these tests; the ratings presented in this chapter don't entirely meet them either. But they are an improvement.

Two ratings, Rating A and Rating B, are calculated and printed for each industry. Each firm also receives two ratings, Rating A and Rating B. The connection between the firm and industry ratings is rather loose. It can be said that the A's are long-run measures, whereas the B's evaluate short-run performance. For grading purposes, the A's are certainly more appropriate.

We will discuss first the industry ratings and then the more complicated firm measures.

Rating A - Industries

This is the simplest of all the ratings. In the case of no entry or exit, equation (3.6) gave a firm's average monopoly profit as a function of monopoly price. Multiplication by the original number of firms in the industry gives the industry's average profit from a cartel of the original

firms operating at the monopoly price.

Rating A is actual industry profit as a percentage of this figure. Thus account is taken both of the level of price and of the identity and number of firms. The more firms charging the monopoly price, the lower are total profits -- especially when entry costs are considered, since total industry demand depends only on average price. Rating A penalizes both low prices and net entry.

It has the defect that it will be altered by the error terms. There seems no conceptually appealing way around this, however, in the case where the current firms in an industry are not the same ones that began there. Programming ease and an abiding faith in the law of large numbers clinch the argument.

Rating B - Industries

Rating B does not penalize entry. It is actual industry profits as a percentage of the average maximum profits that could be earned by the firms actually operating in the industry in the period in question. As usual, we assume that all players are expected value maximizers. Thus their strategy for maximum industry profit is to charge the higher of monopoly price and the price that yields an average demand of 100,000 units -- as discussed in Chapter V.

As with Rating A, we deal with the average best profit by calculating the maximum profit assuming zero error terms. This is a real drawback only when the best strategy for the industry is to sell to capacity, when we will slightly overstate maximum average profit. This happens only when there

has been considerable net exit. Entry costs and side payments are taken into account, of course.

The sense in which the two industry ratings are short-run and long-run measures should be clear. Rating A compares actual profits with those that would be earned (on average) by a well run cartel of the original firms, a cartel that has managed to discourage entry. Rating B takes as given the sellers in the market and compares their total profit with the best that they could earn.

Rating A - Firms

As above, we begin with the long-run measure. Rating A compares the profits actually earned by a firm with the profits it would have earned had it been a member of the well run cartel considered in the Rating A for its industry of origin. The error term experienced is taken into account in a rather complicated way.

It is assumed that GRNUM would have given the firm the same standardized normal error term had the firm been safely established in its cartel. But the actual value of the error experienced may be different because the standard deviation actually applying to a firm may be different than the standard deviation that would have applied had the firm been in its original industry with no net entry.

It may be helpful to resort to a few symbols. Let

o = the original industry

c = the current industry

$SDP(i)$ = the standard deviation of the error term in industry i as it appears on the industry card

M = original number of firms in industry c

N = current number of firms in industry c

e = the error actually added onto the firm's demand function

Then the standard deviation that actually applied to the firm is just $1000\ SDP(c)\ M/N$, and $e\ N\ /\ (1000\ SDP(c)\ M)$ is the standardized normal variable produced by GRNUM. (See Chapter IV if this is unclear.) The standard deivation that would have applied to industry o in the case of no net entry is simply $1000\ SDP(o)$. To get the error that the firm would have experienced, we multiply the standardized variable calculated above by this standard deviation, obtaining $u = e\ (SDP(o)\ /\ (SDP(c)\ M/N))$. (A glance at the main program in Appendix D may be more productive than re-reading this.)

Given u, the error that the firm is assumed to have encountered had it been in the cartel, its assumed profits are the average no-entry monopoly profits as given by equation (3.6) for the firm's original industry plus u (monopoly price -\$.50). We thus obtain our standard.

This may not be as unreasonable as it seems. What we are assuming is that if the firm had a favorable error term today, it would have had one no matter which industry it operated in. Mechanically, this is not necessarily true, but the alternative of assuming a zero error term is rather unpalatable. Notice also that if the firm is in its original industry and if there has been no net entry, $e = u$. It is only when entry has in fact

taken place that we assume the firm would have experienced an error term different in magnitude from the one it did in fact encounter. In all cases, e and u have the same sign.

Rating G - Firms

Rating B is an attempt to approximate the ratio of actual profits to the best profits that the firm could have earned given its competitors' prices. The problem here is unfilled orders.

To compute best profits correctly, we would have to take the best price for each firm (which is calculated as shown in Chapter V) and go through the computation of sales, profits, and unfilled orders outlined in Chapter IV once for each firm. In these calculations, one firm after another would be assumed to be charging its short-run profit-maximizing price, and the actual profits it would have received would be calculated. Needless to say, this would take a good deal of computer time -- more than can be justified in obtaining what usually amounts to no more than a measure of the profitability of cheating or of cheating further.

Instead, we calculate the firm s demand by substituting its best price and the actual average price of its competitors into its demand function, adding the error term actually experienced and the unfilled orders, if any, that it picked up from competitors. If the firm actually received some unfilled orders, this may be a fair approximation to the number it would receive if it changed its price a small amount. As Chapter IV may have made clear, a decrease (increase) in price will raise (lower) a firm's chare of unfilled order pickups. But lowering (raising) its price will

lower (raise) the demands of competitors and hence lower (raise) the number of unfilled orders up for grabs. If the firm received no unfilled orders because it sold to capacity, there are obviously problems.

In any case, "best" sales are taken as the smaller of demand so calculated and 100,000. The corresponding profit is then computed, taking into account any entry costs incurred and side payments made or received. Rating B is then computed as the ratio of actual profit to the absolute value of maximum profit so calculated. The absolute value is used to take into account (unlikely) situations where the best a firm can do is to take a small loss and it, in fact, suffers a large loss. It deserves a negative rating in these cases.

It is possible to get a Rating B of greater than 100%: this is perhaps the main flaw in this measure. If the firm receives a positive error term so that it sells 100,000 units at a price above its best price, it would obviously also sell 100,000 units if it lowered its price to the (on average) best price. It would receive lower profits, however, and its Rating B will thus be greater than 100%.

It should by now be obvious that none of these ratings are entirely satisfactory in the way they deal with the error terms. We have tried to argue that they approach the problem sensibly, but that doesn't prevent their being somewhat arbitrary. There really seems no way around it: if you want to be able to evaluate performance fairly and reasonably, keep the error standard deviations small -- certainly no more than 10,000.

Appendix A

Mnemonic Formats of Input Cards

All variables beginning with "I" or "N", such as IPN and NFO, are integers and do not require a decimal point. All other fields do require a decimal point. All menmonics used here are explained in Appendix B and are used in the GLOOM programs. The makeup of an input deck is described in Chapter II.

Title Card

Columns	Variable
01 - 02	NIT
03 - 04	NP
05 - 06	IPN
07 - 08	ISN
09 - 10	IAR
11 - 80	COMT(1)...COMT(18)

Industry Card (Industry I)

Columns	Variable
01 - 02	I
03 - 04	NFO(I)
05 - 06	ISC(I)
07 - 08	IOC(1,I)
09 - 10	IOC(2,I)
11 - 12	IOC(3,I)
13 - 14	IOC(4,I)
15 - 20	PMA(I)
21 - 26	PC*
27 - 34	FK*
35 - 40	SDP(I)
41 - 46	SCR**
47 - 54	ECA**

* Only one of these needs to be present -- see Chapter III

** Both are zero if entry is not permitted; only one needs to be non-zero if entry is allowed -- see Chapter III

Firm Card (Firm IIJJ)

Columns	Variable
01 - 02	II
03 - 04	JJ
05 - 06	IK*
07	ION(II,JJ)
08- 13	AP(II,JJ)
14 - 15	JI**
16 - 17	JJ**
18 - 25	S**

* To be left blank if the firm is operating in Industry II

** To be left blank unless a side payment is being made

Appendix B

Mnemonics Used in GLOOM

General

COMT(K), K=1,18	Comment
NIT	Total Number of Industries
NP	Period Number
IPN	Number of Parameter Summaries to be printed
ISN	Number of Side Payment Summaries to be printed
IAR	Number of Average Rating Summaries to be printed
NFT	Total Number of Firms

Industries

NFO(I)	Original Number of Firms
NFA(I)	Actual Number of Firms
IEC(I)	Entry Code -- Zero if no entry, one if entry

ISC(I)	Side Payment Code -- Zero if no side payments, one if they are allowed
IOC(1,I)	Output Code 1 -- the number of copies of instructor's output to be printed
IOC(2,I)	Output Code 2 -- the information to be given on other industries on student's interim output
IOC(3,I)	Output Code 3 -- the information to be given on other firms in the current industry on student's interim report
IOC(4,I)	Output Code 4 -- the number of copies of student's summary output to be printed per firm. If negative, ION (I,J) copies will be printed
SDP(I)	The Standard Deviation of the Error Term in thousands
AB(I)	Average value of the intercept term (A) of the demand function
B(I)	Own price coefficient in the demand function
C(I)	Others' average price coefficient in the demand function
ECR	Entry cost as a percentage of average monopoly profit PRM(I)
ECA	Entry Cost in Dollars
EC(I)	Entry Cost in Dollars -- Zero if IEC(I) is zero

PRM(I)	Average Monopoly Profit with no entry
PM	Monopoly Price
PMA(I)	Monopoly Price
PC	Critical Price
PCA(I)	Critical Price
FK	See Chapter III
PB(I)	Average Price
TPR(I)	Total Profits
TS(I)	Total Sales
EP(I)	Best Price for an entrant -- Zero if IEC(I) is zero
EPR(I)	Best Profit for an entrant -- Zero if IEC(I) is zero
RAI(I)	Rating A
RBI(I)	Rating B

Firms

IK	Industry the firm is to operate in
JI	First two digits of the name of the firm to receive a side payment

JJ	Second two digits of the name of the firm to receive a side payment
S	Amount of the side payment
IFN(1,I,J)	First two digits of the firm name
IFN(2,I,J)	Second two digits of the firm name
AA(I J)	Actual value of the intercept term of the demand function (A) experienced
AP(I J)	Price
APR(I,J)	Profits
ASA(I.J)	Sales
AUO(I,J)	Unfilled orders
FC(I,J)	Fixed costs
PBO(I J)	Average of competitors' prices
PS(I,J)	Best Price
PBOE(I J)	"Expected' average of competitors' prices
RAF(I J)	Rating A
RBF(I,J)	Rating B

Appendix C

Description and Listing of GRNUM*

GRNUM is the subroutine utilized by GLOOM to generate normally distributed random numbers with specified mean and standard deviation. These numbers are used to produce successive values of X_1, X_2, and the error term u. This Appendix will briefly explain how GRNUM performs this function.

GRNUM receives from the calling program values for CT, SD, and S. It then (1) generates two random numbers uniformly distributed between zero and one and (2) transforms them into a single normally distributed random number with mean CT and standard deviation SD. This number is returned to the calling program as RN. A new value for S is also returned. We will discuss these operations in turn.

The uniformly distributed random numbers are generated by the multiplicative congrunetial method. That is, a sequence of X's is generated according to

(A.1) $$X_{n+1} \equiv A\ X_n \pmod{M}^{**}$$

---

*This Appendix and GRNUM borrow heavily from A.K. Dixit, "Stochastic Simulation in Econometrics: A First Report," Econometricks Memo #2, Department of Economics, MIT, July, 1967.

**The expression $X \equiv Y \pmod{M}$ means that $(Y-X)$ is exactly divisible by M. In equation (A.1), X_{n+1} is equal to M times the fractional part of $(A\ X_n / M)$. For example, $1 = 8 \pmod{7}$, $5 = 15 \pmod{10}$. GRNUM uses $M = 10^5$, and we have $83542 = 7583542 \pmod{10^5}$.

Then the sequence (X_n/M) is used as independent random numbers uniformly distributed over the interval zero to one. We generate a deterministic sequence that "looks like" a set of random numbers.

Here $M = 10^5$, and X_0 is the value of S taken from the GLOOM main program and referred to there as SED. The value computed as X_2 is returned as the new value for S. The value of A chosen yields low serial correlation in the X's and gives that sequence the maximum period (5,000) possible with $M = 10^5$. The values of A and M were chosen for the 1620. For other machines,other values will be better. See the paper by Dixit for guidance in choosing them.

The two uniformly distributed "random" numbers Y_1 ($=X_1/M$) and Y_2 ($=X_2/M$) are transformed into a normally distributed random number according to an exact transformation suggested by Box and Mueller***. To obtain two independent normal deviates with mean zero and standard deviation one, we can calculate

$$\begin{aligned} Z_1 &= \sqrt{-2\ln(Y_1)} \quad \cos(2\ Y_2) \\ Z_2 &= \sqrt{-2\ln(Y_1)} \quad \sin(2\ Y_2) \end{aligned} \tag{A.2}$$

Then $(Z_1 + Z_2)$ will have mean zero and standard deviation $\sqrt{2}$, and

$$RN = CT + (Z_1 + Z_2)\ SD\ /\sqrt{2} \tag{A.3}$$

will be normal with mean CT and standard deviation SD, as required. Successive observation of RN will be independent.

***G.E.P. Box and M. E. Miller, "A Note on the Generation of Normal Deviates," Ann. Math., Stat., 29, (1958), pp. 610-11. Discussed in Dixit, op. cit.

As a test, 500 successive (different) values of RN were generated by GRNUM. These had a first order serial correlation coefficient of .05. A chi-square test for goodness of fit to the normal distribution was performed, with 7 degrees of freedom. The value of chi-square was less than 5, indicating quite a good fit. Inspection of the frequency distribution confirmed this.

A listing of GRNUM follows.

A Listing of GRNUM

```
      SUBRØUTINE GRNUM (RN, CT, SD, S)
      DIMENSIØN V(2)
      A = 283.
      DØ 01 1=1,2
      F=A*S/10.**5
      K=F
      FK=K
      V(1)=F-FK
01    S=C(1)*10.**5
      A=(-LØGF(V(1)))**.5
      R=6.2831853*V(2)
      B=CØSF(R)+SINF(R)
      RN=CT+SD*A*B
      RETURN
      END
```

APPENDIX - U

LISTING OF GLOOM - THE MAIN PROGRAM

```
1000 FORMAT(5I2,A2,17A4)
1001 FORMAT(1H1,9X,A2,17A4)
1002 FORMAT(10X,7HPERIOD ,I2)
      DIMENSION NFO(10),NFA(10),IEC(10),ISC(10),SDP(10),AB(10),B(10),C(1
     10),EC(10),PRM(10),PR(10),TS(10),EP(10),EPR(10),RAI(10),RBI(10),PMA
     1(10),COMT(18),TPR(10),F(10)
      DIMENSION IOD(10,10),IOC(4,10),AA(10,10),AP(10,10),APR(10,10),ASA(
     110,10),AOT(10,10),IFN(2,10,10),FC(10,10),PBO(10,10),PS(10,10),PBOE
     1(10,10),RAF(10,10),RBF(10,10)
      DIMENSION D(10),SH(10)
C         ***************************************************************
C
C              READ THE TITLE CARD, PRINT COMMENT, PUNCH NEW TITLE CARD
C
      READ 1000,NII,NP,IPN,ISN,IAR,(COMT(J),J=1,18)
      PRINT 1001,(COMT(J),J=1,18)
      PRINT 1002,NP
      I=NP+1
      PUNCH 1000,NII,I,IPN,ISN,IAR,(COMT(J),J=1,18)
C
C              CALL GRNUM NP TIMES TO CHANGE THE ERROR SEQUENCE
C
      SEED=54732.
      DO 20 I=1,NP
 20   CALL GRNUM (X,0.0,1.0,SEED)
C         ***************************************************************
C
C              WE NEXT CALL RGIN TO READ THE INDUSTRY AND FIRM CARDS -
C              ALSO TO PRINT PARAMETER AND SIDE PAYMENT SUMMARIES
```

```
C
      CALL RGIN(NIT,IPN,NFO,IFC,IOC,ISC,SUP,AB,B,C,EC,PRM,COMT,NP,PMA,NF
     1A,ISN,AP,IFN,FC,ION)
C         ******************************************************************
C
C                THIS NEXT BLOCK ADJUSTS THE DEMAND PARAMETERS FOR ENTRY
C                AND ADDS THE ERROR TERMS
C
      DO 123  I=1,NIT
      IF(NFO(I)-NFA(I)) 21,22,21
 22   F(I) =1.
      GO TO 121
 21   FO=NFO(I)
      FA=NFA(I)
      IF(FA) 127,127,112
 127  F(I) =1.
      GO TO 123
 112  F(I) = FO/FA
 121  AB(I) = AB(I)*F(I)
      B(I) = B(I)*F(I)
      C(I) = C(I)*F(I)
      SD = SUP(I)*1000.*F(I)
      NA=NFA(I)
      DO 23 J=1,NA
      CALL GENJ1(X,0.0,SD,SED)
 23   AA(I,J)=AB(I)+X
 123  CONTINUE
C         ******************************************************************
C
C                THIS NEXT LARGE BLOCK CALCULATES SALES, PROFITS, AND
C                UNFILLED ORDERS - ALONG WITH VARIOUS INDUSTRY AVERAGES
C                AND TOTALS
C
      DO 99 I=1,NIT
C
C                COMPUTE PRICE AVERAGES AND *TOTAL DEMAND*
C
      FNC=NFA(I)-1
      FN=NFA(I)
      HN=NFA(I)
```

```
C               IF ONE FIRM, TREAT AS TRUE MONOPOLIST (CARTEL OF ONE)
      IF(FN) 99,99,71
 71   IF(FNC) 72,72,73
 72   PB(I)=AP(I,1)
      PBO(I,1) =PB(I)
      TA=AA(I,1)
      GO TO 75
 73   TA=0.
      DO 03 J=1,NN
      TA=TA+AA(I,J)
      PBO(I,J)=0.
      DO 02 K=1,NN
      IF(K-J) 01,02,01
 01   PBO(I,J)=PBO(I,J)+AP(I,K)
 02   CONTINUE
 03   PBO(I,J)=PBO(I,J)/FNC
      PB(I)=(PBO(I,1)*FNC+AP(I,1))/FN
 75   TD=TA+FN*PB(I)*(C(I)-B(I))
C
C               CALCULATE SHARES OF *TOTAL DEMAND*, ZERO UNFILLED ORDERS
C
      DO 05 J=1,NN
      D(J)=AA(I,J)-B(I)*AP(I,J)+C(I)*PBO(I,J)
      IF(D(J)) 04,04,05
 04   TD=TD-D(J)
      D(J)=0.
 05   CONTINUE
      DO 06 J=1,NN
      SH(J)=D(J)/TD
 06   AUO(I,J)=0.
C
C               CALCULATE SALES AND UNFILLED ORDERS - ALLOCATE THE LATTER
C               ACCORDING TO THE SHARES OF TOTAL DEMAND
C
      NUL=0.
      NU=0.
      TU=0.
      UU=0.
      SAU=0.
      TS(I)=0.
```

```
07    DO 13 J=1,NN
      IF(AUU(I,J))08,08,13
08    D(J)=D(J)+UU*SH(J)/(1.-SWU)
      W=D(J)-100000.
      IF(W) 09,09,12
09    IF(D(J)) 10,11,11
10    ASA(I,J)=0.
      GO TO 13
11    ASA(I,J)=D(J)
      GO TO 13
12    AUU(I,J)=W
      TU=TU+W
      NU=NU+1
      SWU=SWU+SH(J)
      ASA(I,J)=100000.
13    TS(I)=TS(I)+ASA(I,J)
      IF(NU-NUL) 16,16,14
14    IF(NU-NFA(I)) 15,16,16
15    UU=TU
      TU=0.
      NUL=NU
      TS(I)=0.
      GO TO 07
16    IPR(I)=0.
      DO 17 J=1,NN
      APR(I,J)=ASA(I,J)*(AP(I,J)-.5) - FC(I,J)
17    IPR(I)=IPR(I)+APR(I,J)
99    CONTINUE
C         ***********************************************************************
C
C               IF ENTRY IS ALLOWED, THIS BLOCK CALCULATES THE BEST ENTRY
C               PRICE AND THE CORRESPONDING PROFIT - IF IEC=0, BOTH =0
C
      DO 26 I=1,NIT
      IF(IEC(I)) 24,24,25
24    EP(I)=0.
      EPR(I)=0.
      GO TO 26
25    FA=NFA(I)
      R=FA/(FA+1.)
```

```
      IF(K) 113,113,114
C              HANDLE SEPARATELY THE CASE WHERE ALL HAVE LEFT
 113  K=NFO(I)
      PT = (100000. - K*AB(I))/(K*(C(I)-B(I)))
      IF(PMA(I) - PT) 301,301,302
 301  EP(I) = PT
      GO TO 303
 302  EP(I) = PMA(I)
 303  EPR(I) = K*(AB(I)+EP(I)*(C(I)-B(I)))*(EP(I)-.50) - (50000.+EC(I))
      GO TO 26
 114  AE=AB(I)*K
      BE=B(I)*K
      CE=C(I)*K
      P1=(AE+CE*PB(I))/(2.*BE) +.25
      P2=(AE+CE*PB(I))/BE - 100000./BE
      IF(P1-P2)27,27,28
 27   EP(I)=P2
      GO TO 29
 28   EP(I)=P1
 29   EPR(I)=(AE-BE*EP(I)+CE*PB(I))*(EP(I)-.50)-(50000.+EC(I))
 26   CONTINUE
C        ************************************************************
C
C              THIS NEXT LARGE BLOCK  CALCULATES RATINGS, ALONG WITH
C              BEST AND EXPECTED PRICES
C
C
C              MAIN LOOP - CALCULATE INDUSTRY RATINGS, BEST AND EXPECTED PRICES
C
      DO 44 I=1,NIT
      FNO=NFO(I)
      FNA=NFA(I)
      NA=FNA
      IF(NA) 115,115,51
 115  RAI(I)=0.
      RBP(I)=0.
      GO TO 44
C              RAI IS ACTUAL PROFITS / AVG. MONOPOLY PROFITS WITH NO ENTRY
 51   PRMTO=FNO*PRM(I)
      RAI(I)=100.*TPR(I)/PRMTO
```

```
      TF=0.
      DO 41 J=1,NA
 41   TF=TF+FC(I,J)
C                RBI IS ACTUAL PROFITS / ACTUAL AVERAGE BEST PROFIT - THIS
C                MAY NOT BE MONOPOLY PROFIT, SINCE PB = PM MAY GIVE
C                UNFILLED ORDERS
      X=AB(I)+PMA(I)*(C(I)-B(I))
      IF(X-100000.) 101,101,102
 101  PRMTA=FNA*(AB(I)+PMA(I)*(C(I)-B(I)))*(PMA(I)-.50)-TF
      GO TO 103
 102  P = (100000.-AB(I))/(C(I)-B(I))
      PRMTA=FNA*100000.*(P-.50) - TF
 103  RBI(I)=100.*TPR(I)/PRMTA
      IF(NA-1) 55,55,54
C                A MONOPOLY REQUIRES SPECIAL HANDLING - P=PM MAY GIVE UNFILLED
C                ORDERS (A MONOPOLY EXPECTS ITS OWN PRICE)
 55   PBOE(I,1)=AP(I,1)
      PT=(100000.-AB(I))/(C(I)-B(I))
      IF(PT-PMA(I)) 104,104,105
 104  PS(I,1) = PMA(I)
      GO TO 106
 105  PS(I,1)=PT
 106  X=AA(I,1) - PS(I,1)*(C(I)-B(I))
      IF(X-100000.) 108,108,107
 107  X=100000.
 108  BPR=X*(PS(I,1)-.50) - FC(I,1)
      RBF(I,1)=100.*APR(I,1)/BPR
      GO TO 44
 54   DO 44 J=1,NA
C                GENERAL CALCULATION OF BEST PRICE GIVEN PBO
      CF= AB(I) + C(I)*PBO(I,J)
      P1=CF/(2.*B(I)) + .25
      P2 = CF/B(I) - 100000./B(I)
      IF(P1-P2) 31,31,32
 31   PS(I,J)=P2
      GO TO 33
 32   PS(I,J)=P1
C                RBF IS ACTUAL PROFIT / BEST PROFIT GIVEN OTHERS PRICES
C                THE SAME NUMBER OF UNFILLED ORDERS PICKED UP IS ASSUMED
 33   SAL = AA(I,J) - B(I)*AP(I,I) + C(I)*PBO(I,J)
```

```
      IF(SAL) 202,202,201
 201  IF(SAL - 100000.) 205,204,204
 204  SAL = 100000.
 205  UNF = ASA(I,J) - SAL
      GO TO 203
 202  UNF = 0.
 203  W=AA(I,J) - B(I)*PS(I,J) + C(I)*PRO(I,J)+ UNF
      IF(W-100000.)  110,110,109
 109  W=100000.
 110  BPR=W*(PS(I,J)-.50) - FC(I,J)
      RBF(I,J)=100.*APR(I,J)/ABSF(BPR)
C               GENERAL CALCULATION OF EXPECTED PRICE GIVEN AP
      T=100000./B(I) +.50
      IF(AP(I,J)-T) 42,42,43
 42   PBOE(I,J)=(4.*C(I)*AP(I,J)-2.*AB(I)-B(I))/(2.*C(I))
      GO TO 44
 43   PBOE (I,J)=(B(I)*AP(I,J)-AA(I)+100000.)/C(I)
 44   CONTINUE
C
C               MAIN LOOP - CALCULATE RAF, ACTUAL PROFITS / MONOPOLY PROFIT
C               IN ORIGINAL INDUSTRY - ALLOWING FOR THE ERROR EXPERIENCED
C
      DO 55 I=1,NII
      NA=NFA(I)
      IF(NA) 55,55,65
 65   DO 55 J=1,NA
      E=AA(I,J)-AB(I)
C               (IO IS THE ORIGINAL INDUSTRY NUMBER)
      IO=IFN(1,I,J)
 63   IF(SUP(I)) 64,64,76
 64   E = 0.
      GO TO 36
C               GENERAL RE-SCALING OF THE ACTUAL ERROR TERM
 76   E = E * SUP(IO)/(SUP(I)*F(I))
 36   STD=PRM(IO)+E*(PMA(IO)-.50)
      RAF(I,J)=100.*APR(I,J)/STD
 55   CONTINUE
C       ***************************************************************************
C
C               THIS IS A CALL TO PROUT TO PRINT STUDENTS AND INSTS
```

```
C               OUTPUT
C
      CALL PGOUT(IOC,COMT,NP,NFA,NFO,NIT,AP,APR,ASA,AUD,IFN,RAF,RBF,PS,P
     1BOE,EP,EPR,IS,IPR,PR,RAI,RBI,PBU,IUN)
C         ***********************************************************
C
C               FINALLY, WE CALL CAR TO UPDATE THE HISTORY CARDS AND TO
C               PRINT AVERAGE RATINGS TO DATE
C
      CALL CAR(NIT,NFA,NFO,NP,IAR,IFN,RAI,RBI,RAF,RBF,IEC,COMT)
      CALL EXIT
      END
```

APPENDIX - E

LISTING OF SUBROUTINE RGIN

```
      SUBROUTINE RGIN (NIT,IPN,NFU,IEC,IOC,ISC,SUP,AB,B,C,EC,PRM,COMT,NP
     1,PMA,NFA,ISN,AP,IFN,FC,ION)
      DIMENSION NFU(10),IEC(10),IOC(4,10),ISC(10),SUP(10),AB(10),B(10),C
     1(10),EC(10),PRM(10),COMT(18),PMA(10)
      DIMENSION NFA(10),          AP(10,10),IFN(2,10,10),FC(10,10),ION(10,
     110)
      DIMENSION ISP(5,50),RSP(50),INSP(50),IDUM(50)
      DIMENSION IO(4),PCA(10)
 1000 FORMAT(1H1,9X,A2,17A4)
 1001 FORMAT(10X,7HPERIOD ,I2)
 9999 FORMAT(1H )
C               FORMATS FOR INDUSTRY CARD SECTION
 2000 FORMAT(7I2,2F6.2,F6.0,2F6.2,F8.0)
 2001 FORMAT(1H0,19X,17HPARAMETER SUMMARY)
 2002 FORMAT(9H0INDUSTRY,2X,15HORIGINAL NUMBER,2X,10HENTRY CODE,2X,7HSP
     1CODE,2X,12HOUTPUT COEFS,2X,7HM-PRICE,2X,7HC-PRICE,4X,9HSTD. DEV.,6
     1X,10HENTRY COST)
 2003 FORMAT(4X,I2,12X,I2,13X,I1,9X,I1,8X,I2,2X,I2,5X,F6.2,3X,F6.2,5X,F9
     1.3,4X,F12.2)
C               FORMATS FOR FIRM CARD SECTION
 1002 FORMAT(3I2,I1, F6.2,2I2,F8.0)
 1003 FORMAT(1H0,9X,26HNO SIDE PAYMENTS WERE MADE)
 1004 FORMAT(1H0,9X,21HLIST OF SIDE PAYMENTS)
 1005 FORMAT(1H0,6HNUMBER,5X,5HPAYER,5X,8HINDUSTRY,5X,5HPAYEE,5X,6HAMOUN
     1T)
 1006 FORMAT(3X,I2,8X,2I2,6X,I2,9X,2I2,F11.2)
 1007 FORMAT(1H0,4X,49HTHE FOLLOWING SIDE PAYMENTS COULD NOT BE ACCEPTED
     1)
 1008 FORMAT(25X,I2)
```

```
C
C               THE FIRST TASK IS TO READ THE NIT INDUSTRY CARDS, CALCULATE
C               PARAMETERS, AND PRINT REQUIRED PARAMETER SUMMARIES
C
C               FIRST LOOP - READ AND ASSIGN PARAMETERS
C
      DO 88 K=1,NIT
C               READ AN INDUSTRY CARD
      READ 2000,I,NF,IS,(IO(J),J=1,4),PM,PC,FK,SD,ECR,ECA
C                ASSIGN OBVIOUS PARAMETERS
      PMA(I)=PM
      ISC(I)=IS
      NFM(I)=NF
      SDP(I)=SD
      DO 31 J=1,4
 31   IOC(J,I)=IO(J)
C               GIVEN EITHER FK OR PC, COMPUTE THE OTHER
      IF(FK) 33,32,33
 32   FK=(400000.*(2.*PM-1.)*(1.-PC))/((4.*PM-3.)*(2.*PC-1.))
      PCA(I)=PC
      GO TO 34
 33   PCA(I)=(400000.*(2.*PM-1.)+FK*(4.*PM-3.))/(400000.*(2.*PM-1.)+2.*F
     1K*(4.*PM-3.))
C               COMPUTE AVERAGE A,B,C, AND AVG. MONOPOLY PROFIT
 34   AB(I)=100000.*(4.*PM-1.)/(4.*PM-3.)
      B(I)=2.*FK + 200000.
      C(I)=2.*FK + 800000.*(PM-1.)/(4.*PM-3.)
      PRM(I)=200000.*(PM-1.)**2/(4.*PM-3.)
C               IF ECA AND ECR = 0, IEC = 0 - IF NOT, GET ECA
      IF(ECA+ECR) 36,35,36
 35   IEC(I)=0
      EC(I)=0.
      GO TO 88
 36   IEC(I)=1
      IF(ECA) 37,38,37
 37   EC(I)=ECA
      GO TO 88
 38   EC(I)=ECR*PRM(I)/100.
 88   CONTINUE
C
```

```
C                 SECOND MAIN LOOP, PRINT IPN PARAMETER SUMMARIES
C
      IF(IPN) 66,66,39
 39   DO 40 K=1,IPN
      PRINT 1000,(COMT(J),J=1,18)
      PRINT 1001,NP
      PRINT 9999
      PRINT 2001
      PRINT 2002
      DO 40 I=1,NIT
 40   PRINT 2003,I,NFO(I),IFC(I),ISC(I),IUC(2,I),IUC(3,I),PMA(I),PCA(I),
     1SDP(I),EC(I)
 66   CONTINUE
C
C                 WE NOW ZERO NFA AND CALCULATE NFI - TOTAL NUMBER OF FIRMS
C
      NFI=0
      DO 67 I=1,NIT
      NFI=NFI+NFO(I)
 67   NFA(I)=0
C
C                 THE NEXT MAIN TASK IS TO READ THE NFI FIRM CARDS, AND
C                 DEAL WITH ENTRY AND SIDE PAYMENTS - PRINTING ISN SIDE
C                 PAYMENT SUMMARIES
C
C
C                 FIRST MAIN LOOP - READ THE NFI FIRM CARDS
C
      NSP=0
      DO 08 KK=1,NFI
      READ 1002,II,IJ,IK,NCO,P,JI,JJ,S
C                 PLACE IN CURRENT INDUSTRY - ADJUST FC IF ENTRANT
      IF(IK) 02,02,03
 02   I=II
      F=0.
      GO TO 05
 03   IF(IEC(IK))02,02,04
 04   I=IK
      F=1.
 05   NFA(I)=NFA(I)+1
```

```
      J=NFA(I)
      AP(I,J)=P
      ICON(I,J)=NCO
      IFN(1,I,J)=II
      IFN(2,I,J)=IJ
      FC(I,J)=50000.+F*FC(I)
C                DEBIT AND RECORD ANY LEGAL SIDE PAYMENT
      IF(S) 06,08,06
 06   IF(ISC(I)) 08,08,07
 07   NSP=NSP+1
      S=ABSF(S)
      FC(I,J)=FC(I,J)+S
      RSP(NSP)=S
      IDUD(NSP)=1
      ISP(1,NSP)=II
      ISP(2,NSP)=IJ
      ISP(3,NSP)=I
      ISP(4,NSP)=JI
      ISP(5,NSP)=JJ
 08   CONTINUE
C
C               CREDIT PAYMENTS THAT CAN BE ACCEPTED - RECORD OTHERS
C
      IF(NSP) 09,69,09
 09   DO 15 I=1,NIT
      NN=NFA(I)
      IF(ISC(I)) 15,15,13
 13   DO 15 K=1,NSP
      DO 15 J=1,NN
      IF(ISP(4,K)-IFN(1,I,J)) 15,14,15
 14   IF(ISP(5,K)-IFN(2,I,J)) 15,15,15
 15   FC(I,J)=FC(I,J)-RSP(K)
      IDUD(K)=0
 15   CONTINUE
      NISP=0
      DO 17 I=1,NSP
      IF(IDUD(I)) 18,17,18
 18   NISP=NISP+1
      INSP(NISP)=I
 17   CONTINUE
```

```
C
C                PRINT ISA SIDE PAYMENT SUMMARIES
C
 09   IF(ISN) 77,77,19
 19   DO 99 K=1,ISN
      PRINT 1000,(COMT(I),I=1,18)
      PRINT 1001,NP
      IF(NSP) 20,20,21
 20   PRINT 1003
      GO TO 99
 21   PRINT 9999
      PRINT 1004
      PRINT 1005
      DO 22 I=1,NSP
 22   PRINT 1006,I,(ISP(J,I),J=1,5),RSP(I)
      IF(NISP) 99,99,23
 23   PRINT 1007
      DO 24 I=1,NISP
 24   PRINT 1008,INSP(I)
 99   CONTINUE
 77   CONTINUE
      RETURN
      END
```

APPENDIX - F

LISTING OF SUBROUTINE PGOUT

```
      SUBROUTINE PGOUT (IOC,COMT,NP,NFA,NFO,NIT,AP,APR,ASA,AUO,IFN,RAF,R
     1BF,PS,PBOE,EP,EPR,TS,TPR,PB,RAI,RBI,PBO,ION)
      DIMENSION IOC(4,10),COMT(18),NFA(10),NFO(10),AP(10,10),APR(10,10),
     1ASA(10,10),AUO(10,10),IFN(2,10,10),RAF(10,10),RBF(10,10),PS(10,10)
     1,PBOE(10,10),PBO(10,10),ION(10,10)
      DIMENSION EP(10),EPR(10),TS(10),TPR(10),PB(10),RAI(10),RBI(10)
 1001 FORMAT(1H1,9X,A2,17A4)
 9999 FORMAT(1H )
C               FORMATS FOR INSTRUCTORS OUTPUT
 1000 FORMAT(10X,30HINSTRUCTORS OUTPUT - INDUSTRY ,I2,9H, PERIOD ,I2)
 1002 FORMAT(1H0,4X,9HNET ENTRY,I3)
 1003 FORMAT(1H0,9X,38HBELIEVE IT OR NOT, ALL FIRMS HAVE LEFT)
 1004 FORMAT(1H0,4X,14HAVERAGE PRICE ,F6.2)
 1005 FORMAT(5X,12HTOTAL SALES ,F12.2)
 1006 FORMAT(5X,12HTOTAL PROFIT ,F12.2)
 1007 FORMAT(1H0,4X,12HENTRY PRICE ,F6.2)
 1008 FORMAT(5X,12HENTRY PROFIT ,F12.2)
 1009 FORMAT(1H0,4X,9HRATING A ,F7.2)
 1010 FORMAT(5X,9HRATING B ,F7.2)
 1012 FORMAT(1H0,14X,28HFIRMS SELLING IN THIS MARKET)
 1013 FORMAT(4X ,6HNUMBER,2X,5HPRICE,6X,5HSALES,5X,7HPROFITS,3X,15HUNFIL
     1LED ORDERS,3X,8HRATING A,2X,10HBEST PRICE,3X,8HRATING B,2X,8HACT.
     1PBO,2X,8HEXP. PBO)
 1014 FORMAT(5X,2I2,2X,F6.2,3X,F10.2,2X,F10.2,4X,F10.2,3X,F9.2,5X,F6.2,3
     1X,F9.2,4X,F6.2,4X,F6.2)
C               FORMATS FOR STUDENTS OUTPUT
 8000 FORMAT(10X,31HSTUDENTS SUMMARY OUTPUT - FIRM ,2I2,9H, PERIOD ,I2)
 8001 FORMAT(10X,31HSTUDENTS INTERIM OUTPUT - FIRM ,2I2,9H, PERIOD ,I2)
 8002 FORMAT(1H0,9X,19HINDUSTRY STATISTICS)
 8003 FORMAT(1H0,8HINDUSTRY,2X,10HORIG. NUM.,2X,9HACT. NUM.,2X,10HAVG. P
     1RICE,5X,11HTOTAL SALES,5X,12HTOTAL PROFIT)
```

```
8004 FORMAT(4X,I2,9X,I2,10X,I2,7X,F6.2,6X,F12.2,5X,F12.2)
8005 FORMAT(1H0,9X,28HFIRMS IN CURRENT INDUSTRY - ,I2)
8006 FORMAT(1H0,9X,29HFIRMS IN ORIGINAL INDUSTRY - ,I2)
8007 FORMAT(1H0,6X,34HFIRM IS STILL IN ORIGINAL INDUSTRY)
8008 FORMAT(1H0,4HFIRM,5X,5HPRICE,8X,5HSALES,8X,7HPROFITS,5X,15HUNFILLE
    1D ORDERS)
8009 FORMAT(1X,2I2,4X,F6.2,5X,F10.2,5X,F10.2,5X,F10.2)
8010 FORMAT(1H0,14X,13HALL HAVE LEFT)
8011 FORMAT(4X,I2,9X,I2,5X,13HALL HAVE LEFT)
C
C              THE FIRST TASK IS TO PRINT IOC(1,I) COPIES OF THE
C              INSTRUCTORS OUTPUT - WHICH GIVES JUST ABOUT ALL
C              POSSIBLE INFORMATION
C
      DO 99 I=1,NIT
      NA=NFA(I)
      NC=IOC(1,I)
      IF(NC) 99,99,11
 11   DO 99 KK=1,NC
      PRINT 1001,(COMT(J),J=1,18)
      PRINT 1000,I,NP
      IF(NA) 200,200,02
 200  IF(EP(I)) 01,01,201
 201  PRINT 1007, EP(I)
      PRINT 1008,EPR(I)
 01   PRINT 1003
      GO TO 99
 02   NE=NA-NFO(I)
      PRINT 1002,NE
      PRINT 1004,PB(I)
      PRINT 1005,TS(I)
      PRINT 1006,TPR(I)
      IF(EP(I)) 04,04,03
 03   PRINT 1007,EP(I)
      PRINT 1008,EPR(I)
 04   PRINT 1009,RAI(I)
      PRINT 1010,RBI(I)
      PRINT 9999
      PRINT 1012
      PRINT 9999
      PRINT 1013
      DO 88 J=1,NA
```

```
 88   PRINT 1014,IFN(1,I,J),IFN(2,I,J),AP(I,J),ASA(I,J),APR(I,J),AUO(I,J
     1),RAF(I,J),PS(I,J),RBF(I,J),PBO(I,J),PBOE(I,J)
 99   CONTINUE
C
C               THIS BLOCK PRINTS IOC(4,I) COPIES OF STUDENTS SUMMARY
C               OUTPUT FOR EACH FIRM IN INDUSTRY I. IF IOC(4,I) IS LESS
C                 THAN ZERO, ION(I,J) COPIES ARE PRINTED.
C
      DO 810 I=1,NIT
      NA=NFA(I)
C               CHECK TO SEE IF ANY FIRMS ARE PRESENT
      IF(NA) 810,810,701
 701  DO 810 J=1,NA
      IF(IOC(4,I)) 801,810,802
 801  KC=ION(I,J)
      GO TO 803
 802  KC=IOC(4,I)
 803  DO 809 K=1,KC
C               PRINT IDENTIFIERS
      PRINT 1001,(COMT(L),L=1,18)
      PRINT 8000,IFN(1,I,J),IFN(2,I,J),NP
      PRINT 9999
C               PRINT INFORMATION ON ALL INDUSTRIES
      PRINT 8002
      PRINT 8003
      DO 804 L=1,NIT
      IF(NFA(L)) 101,101,102
 101  PRINT 8011,L,NFO(L)
      GO TO 804
 102  PRINT 8004,L,NFO(L),NFA(L),PB(L),TS(L),TPR(L)
 804  CONTINUE
      PRINT 9999
C               PRINT INFORMATION ON FIRMS IN THE CURRENT INDUSTRY
      PRINT 8005,I
      PRINT 8008
      DO 805 L=1,NA
 805  PRINT 8009,IFN(1,I,L),IFN(2,I,L),AP(I,L),ASA(I,L),APR(I,L),AUO(I,L
     1)
C               IF THE FIRM IS AN ENTRANT, GIVE INFORMATION ON FIRMS IN
C               ITS ORIGINAL INDUSTRY
      IF(IFN(1,I,J)-I) 807,806,807
 806  PRINT 8007
```

```
      GO TO 809
  807 IO=IFN(1,I,J)
      PRINT 9999
      PRINT 8006,IO
      NO=NFA(IO)
      IF(NO) 811,811,812
  811 PRINT 8010
      GO TO 809
  812 PRINT 8008
      DO 808 L=1,NO
  808 PRINT 8009,IFN(1,IO,L),IFN(2,IO,L),AP(IO,L),ASA(IO,L),APR(IO,L),AU
     1O(IO,L)
  809 CONTINUE
  810 CONTINUE
C
C              THE NEXT TASK IS TO PRINT ION(I,J) COPIES OF STUDENTS
C              INTERIM OUTPUT - GIVING ONLY THE INFORMATION CALLED FOR
C              IN IOC(2,I) AND IOC(3,I)
C
      DO 899 I=1,NIT
C              CHECK TO SEE IF ANY FIRMS ARE PRESENT
      NF=NFA(I)
      IF (NF) 899,899,702
C              DECIPHER IOC(2,I) - GIVES INFO TO BE PRINTED ON OTHER
C              INDUSTRIES
  702 F=IOC(2,I)
      FF=F/10.
      IA=FF
      K=F
      IB=K - IA*10
      IF(IA) 822,821,822
  821 NCO=0
      PCO=0.
      GO TO 827
  822 IF(IA-3) 824,823,824
  823 NCO=1
      PCO=1.
      GO TO 827
  824 IF(IA-1) 826,825,826
  825 NCO=1
      PCO=0.
      GO TO 827
```

```
  826   NCO=0
        PCO=1.
  827   IF(IB) 829,828,829
  828   SCO=0.
        RCO=0.
        GO TO 834
  829   IF(IB-3) 831,830,831
  830   SCO=1.
        RCO=1.
        GO TO 834
  831   IF(IB-1) 833,832,833
  832   SCO=1.
        RCO=0.
        GO TO 834
  833   SCO=0.
        RCO=1.
  834   KI=SCO+RCO+PCO
        KI=KI+NCO
C                DECIPHER IOC(3,I) - GIVES INFO TO BE PRINTED ON OTHER
C                FIRMS IN THE CURRENT INDUSTRY
        F=IOC(3,I)
        FF=F/10.
        IA=FF
        K=F
        IB=K-IA*10
        IF(IA) 836,835,836
  835   NCF=0
        IEF=0
        ICF=0
        GO TO 841
  836   IF(IA-1) 838,837,838
  837   NCF=1
        IEF=0
        ICF=0
        GO TO 841
  838   IF(IA-2) 840,839,840
  839   NCF=1
        IEF=1
        ICF=0
        GO TO 841
  840   NCF=1
        IEF=1
```

```
      ICF=1
  841 IF(IB) 843,842,843
  842 PCF=0.
      SCF=0.
      RCF=0.
      GO TO 856
  843 IF(IB-1) 845,844,845
  844 PCF=1.
      SCF=0.
      RCF=0.
      GO TO 856
  845 IF(IB-2) 847,846,847
  846 PCF=0.
      SCF=1.
      RCF=0.
      GO TO 856
  847 IF(IB-3) 849,848,849
  848 PCF=0.
      SCF=0.
      RCF=1.
      GO TO 856
  849 IF(IB-4) 851,850,851
  850 PCF=1.
      SCF=1.
      RCF=0.
      GO TO 856
  851 IF(IB-5) 853,852,853
  852 PCF=1.
      SCF=0.
      RCF=1.
      GO TO 856
  853 IF(IB-6) 855,854,855
  854 PCF=0.
      SCF=1.
      RCF=1.
      GO TO 856
  855 PCF=1.
      SCF=1.
      RCF=1.
  856 KF=PCF+SCF+RCF
      KF=KF+NCF+IEF+ICF
C              AT LONG LAST WE START PRINTING FOR INDUSTRY I
```

```
      DO 899 J=1,NF
      NC=ION(I,J)
      IF(NC) 899,899,867
  867 DO 888 KK=1,NC
C              PRINT IDENTIFIERS
      PRINT 1001,(COMT(L),L=1,18)
      PRINT 8001,IFN(1,I,J),IFN(2,I,J),NP
      PRINT 9999
C              PRINT INFO ON THE INDUSTRIES
      PRINT 8002
      PRINT 8003
      DO 893 L=1,NIT
  876 IF(NFA(L)) 878,878,879
  878 IF(NCO) 893,893,222
  222 PRINT 8011,L,NFO(L)
      GO TO 893
  879 NA=NFA(L)
      P=P8(L)
      S=TS(L)
      R=TPR(L)
      IF(I-L) 858,857,858
  857 NA=NA*NCF
      GO TO 779
  858 IF(KI) 893,893,892
  892 NA=NA*NCO
      P=P*PCO
      S=S*SCO
      R=R*RCO
  779 PRINT 8004,L,NFO(L),NA,P,S,R
  893 CONTINUE
C              PRINT INFO ON FIRMS IN THE CURRENT INDUSTRY
      PRINT 9999
      PRINT 8005,I
      PRINT 8008
      DO 888 L=1,NF
      II=IFN(1,I,L)
      IJ=IFN(2,I,L)
      P=AP(I,L)
      S=ASA(I,L)
      R=APR(I,L)
      U=AUO(I,L)
      IF(L-J) 860,863,860
```

```
860   IF(KF) 888,888,862
862   P=P*PCF
      S=S*SCF
      R=R*RCF
      U=U*SCF
      IF(II-I) 865,864,865
864   II=II*ICF
      IJ=IJ*ICF
865   II=II*IEF
      IJ=IJ*IEF
863   PRINT 8009,II,IJ,P,S,R,U
888   CONTINUE
899   CONTINUE
      RETURN
      END
```

APPENDIX - G

LISTING OF SUBROUTINE CAR

```
      SUBROUTINE CAR (NIT,NFA,NFO,NP,IAR,IFN,RAI,RBI,RAF,RBF,IEC,COMT)
 1001 FORMAT(1H1,9X,A2,17A4)
 9000 FORMAT(10X,37HAVERAGE RATINGS AT THE END OF PERIOD ,I2)
 9999 FORMAT(1H )
 9001 FORMAT(1H0,5X,8HINDUSTRY,6X,8HRATING A,6X,8HRATING B)
 9002 FORMAT(9X,I2,8X,F8.2,6X,F8.2)
 9003 FORMAT(1H0,7X,4HFIRM,8X,8HRATING A,6X,8HRATING B)
 9004 FORMAT(8X,2I2,7X,F8.2,6X,F8.2)
 9005 FORMAT(10F8.2)
      DIMENSION NFA(10),NFO(10),IFN(2,10,10),RAI(10),RBI(10),RAF(10,10),
     1RBF(10,10),IEC(10),COMT(18)
      DIMENSION ARAI(10),ARBI(10),ARAF(10,10),ARBF(10,10)
C
C              THIS ROUTINE READS OLD HISTORY CARDS, PUNCHES NEW ONES,
C              AND PRINTS IAR COPIES OF A SUMMARY OF THE AVERAGE RATINGS
C
      FN=NP
      FNC=FN-1.
C              COMPUTE INDUSTRY AVERAGE RATINGS, READ IF NP IS G.T. ONE
      IF(NP-1) 901,901,903
  901 DO 902 I=1,NIT
      ARAI(I)=RAI(I)
  902 ARBI(I)=RBI(I)
      GO TO 905
  903 READ 9005,(ARAI(K),K=1,NIT),(ARBI(L),L=1,NIT)
      DO 904 I=1,NIT
      ARAI(I)=(RAI(I)+FNC*ARAI(I))/FN
  904 ARBI(I)=(RBI(I)+FNC*ARBI(I))/FN
C                 COMPUTE FIRM AVERAGE RATINGS, READ IF NP IS G.T. ONE
  905 IF(NP-1) 908,906,908
  906 DO 907 I=1,NIT
```

```
      NO=NFO(I)
      DO 907 J=1,NO
      ARAF(I,J)=1.
  907 ARBF(I,J)=1.
      GO TO 910
  908 DO 909 I=1,NIT
      NO=NFO(I)
  909 READ 9005,(ARAF(I,K),K=1,NO),(ARBF(I,L),L=1,NO)
C               FIRST LOOK FOR A FIRM IN ITS ORIGINAL INDUSTRY
  910 DO 918 I=1,NIT
      NO=NFO(I)
      NA=NFA(I)
      DO 918 J=1,NO
      IF(NA) 113,113,112
  112 DO 913 K=1,NA
      IF(IFN(1,I,K)-I) 913,911,913
  911 IF(IFN(2,I,K)-J) 913,912,913
  912 ARAF(I,J)=(RAF(I,K)+FNC*ARAF(I,J)) /FN
      ARBF(I,J)=(RBF(I,K)+FNC*ARBF(I,J))/FN
      GO TO 918
  913 CONTINUE
C               IF IT IS NOT THERE, CHECK INDUSTRIES IT COULD HAVE ENTERED
  113 DO 719 II=1,NIT
      IF(IEC(II))914,719,914
  914 NF=NFA(II)
      IF(NF) 719,719,111
  111 DO 917 JJ=1,NF
      IF(IFN(1,II,JJ)-I) 917,915,917
  915 IF(IFN(2,II,JJ)-J)917,916,917
  916 ARAF(I,J)=(RAF(II,JJ)+FNC*ARAF(I,J))/FN
      ARBF(I,J)=(RBF(II,JJ)+FNC*ARBF(I,J))/FN
      GO TO 918
  917 CONTINUE
  719 CONTINUE
  918 CONTINUE
C               PUNCH NEW AVERAGES ON HISTORY CARDS
      PUNCH 9005,(ARAI(K),K=1,NIT),(ARBI(L),L=1,NIT)
      DO 919 I=1,NIT
      NO=NFO(I)
  919 PUNCH 9005,(ARAF(I,J),J=1,NO),(ARBF(I,K),K=1,NO)
C               PRINT IAR LISTS OF THE NEW AVERAGE RATINGS
      IF(IAR) 999,999,920
```

```
920   DO 988 KK=1,IAR
      PRINT 1001,(COMT(L),L=1,18)
      PRINT 9000,NP
      PRINT 9999
      PRINT 9001
      DO 921 I=1,NIT
921   PRINT 9002,I,ARAI(I),ARBI(I)
      PRINT 9999
      PRINT 9003
      DO 922 I=1,NIT
      PRINT 9999
      NO=NFO(I)
      DO 922 J=1,NO
922   PRINT 9004,I,J,ARAF(I,J),ARBF(I,J)
988   CONTINUE
999   CONTINUE
      RETURN
      END
```

Appendix H

Sample Output

Contents

page

Parameter Summary 73

Side Payment Summary 74

Instructor's Output 75

Students' Interim Output (Output Codes 33 37) 76

Students' Interim Output (Output Codes 00 00) 77

Students' Summary Output 78

Average Rating Summary 79

```
    GLOOM II TEST RUNS - AUGUST, 1968
   PERIOD  2


                PARAMETER SUMMARY

INDUSTRY  ORIGINAL NUMBER  ENTRY CODE  SP CODE  OUTPUT CODES  M-PRICE  C-PRICE    STD. DEV.       ENTRY CUS
    1                 4          0         0        33  37      2.00     1.00        1.000             0.0
    2                 4          1         1         0   0      3.00     1.00        2.000          8888.8
    3                 4          0         1        33  37      2.00      .75        1.000             0.0
    4                 4          1         1         0   0      3.00      .75        1.500         17777.7
```

```
   GLOOM II TEST RUNS - AUGUST, 1968
PERIOD  2


LIST OF SIDE PAYMENTS

NUMBER      PAYER       INDUSTRY       PAYEE       AMOUNT
   1          1 1          2            4 4       100.00
   2          2 4          2            2 1       350.00
   3          4 3          4            4 1       175.00
```

```
        BLOCK II TEST RUNS - AUGUST, 1968
      INSTRUCTORS OUTPUT - INDUSTRY  2, PERIOD  2

 NET ENTRY   1

 AVERAGE PRICE    2.56
 TOTAL SALES      277855.46
 TOTAL PROFIT     279352.65

 ENTRY PRICE    2.13
 ENTRY PROFIT    104777.77

 RATING A    78.56
 RATING B    97.22


           FIRMS SELLING IN THIS MARKET

NUMBER   PRICE        SALES       PROFITS    UNFILLED ORDERS    RATING A  BEST PRICE    RATING B   ACT. PBO   EXP. PB
  1 1    2.90          0.00    -56988.68               0.00     -140.22        2.18      -53.81       2.47      3.27
  2 2    2.50      66195.86     82391.72               0.00       86.04        2.27       64.62       2.57      2.82
  2 3    2.50      65970.88     81941.76               0.00       86.21        2.27       64.26       2.57      2.82
  2 4    2.50      64383.35     76416.70               0.00       87.04        2.27       61.67       2.57      2.82
  3 3    2.40      81305.39     95591.36               0.00      252.28        2.29       81.64       2.60      2.71
```

```
      GLOOM II TEST RUNS - AUGUST, 1968
     STUDENTS INTERIM OUTPUT - FIRM  3 2, PERIOD  2


     INDUSTRY STATISTICS

INDUSTRY  ORIG. NUM.  ACT. NUM.  AVG. PRICE    TOTAL SALES    TOTAL PROFIT
    1          4          3         1.98        240219.65      205785.08
    2          4          5         2.56        277855.48      279352.65
    3          4          3         2.00        242756.10      214134.15
    4          4          5         2.71        100000.00     -157327.77


     FIRMS IN CURRENT INDUSTRY -  3

FIRM      PRICE        SALES        PROFITS     UNFILLED ORDERS
 3 1       2.00       81758.90      72638.35          0.00
 3 2       2.00       80601.70      70902.55          0.00
 3 4       2.00       80395.50      70593.25          0.00
```

```
            GLOOM II TEST RUNS - AUGUST, 1968
          STUDENTS INTERIM OUTPUT - FIRM  3 3, PERIOD  2


          INDUSTRY STATISTICS

INDUSTRY  ORIG. NUM.  ACT. NUM.  AVG. PRICE      TOTAL SALES      TOTAL PROFIT
   2           4           0          2.56        277855.46         279352.65


          FIRMS IN CURRENT INDUSTRY -  2

FIRM      PRICE         SALES         PROFITS     UNFILLED ORDERS
 3 3       2.40        81305.39       95591.36            0.00
```

```
        GLOOM II TEST RUNS - AUGUST, 1968
       STUDENTS SUMMARY OUTPUT - FIRM  3 3, PERIOD  2


       INDUSTRY STATISTICS

INDUSTRY  ORIG. NUM.   ACT. NUM.   AVG. PRICE     TOTAL SALES      TOTAL PROFIT
    1           4           3          1.98        240219.65        205785.08
    2           4           5          2.56        277855.48        279352.65
    3           4           3          2.00        242756.10        214134.15
    4           4           5          2.71        100000.00       -157327.77

       FIRMS IN CURRENT INDUSTRY -  2

FIRM      PRICE         SALES          PROFITS       UNFILLED ORDERS
 1 1      2.90            0.00        -58988.68            0.00
 2 2      2.50        66195.86         82591.72            0.00
 2 3      2.50        65970.88         81941.76            0.00
 2 4      2.50        64383.35         78416.70            0.00
 3 3      2.40        81305.39         95591.36            0.00

       FIRMS IN ORIGINAL INDUSTRY -  3

FIRM      PRICE         SALES          PROFITS       UNFILLED ORDERS
 3 1      2.00        81758.90         72638.35            0.00
 3 2      2.00        80601.70         70902.55            0.00
 3 4      2.00        80395.50         70593.25            0.00
```

```
         GLOOM II TEST RUNS - AUGUST, 1968
       AVERAGE RATINGS AT THE END OF PERIOD  2


    INDUSTRY          RATING A         RATING B
        1              112.64            97.33
        2               39.28            48.61
        3              117.64           101.70
        4              -35.49           -83.60


      FIRM            RATING A         RATING B

      1 1              -77.14           -32.04
      1 2              141.26            69.06
      1 3              169.50            92.14
      1 4              157.72            75.70

      2 1               16.15          -117.10
      2 2               33.71          -216.66
      2 3               41.58             7.32
      2 4               44.74            48.54

      3 1              115.87            51.65
      3 2              116.50            56.75
      3 3              233.67            90.42
      3 4              115.68            49.58

      4 1               -9.78           131.09
      4 2              -22.97            23.53
      4 3              -56.19          -427.57
      4 4              -57.25           -41.71
```

~~OCT 18 '71~~